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Contains a selected and annotated listing of source material concerning the thermal environment in school facilities. It is directed toward the school planner, architect, or administrator concerned with developing a more functional classroom environment. Topical coverage includes--(1) The Thermal Environment and Learning, (2) Physiological Factors in the Thermal Environment, (3) Heating-Ventilating and Air-Conditioning in the Classroom, and (4) Additional Considerations in Planning and Thermal Environment. (Author)

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THERMAL ENVIRONMENT IN SCHOOL FACILITIES

A selected and annotated bibliography

Prepared by
Robert R. Hartmann
1968

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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I N T R O D U C T I O N

Information contained in this selected bibliography concerning the Thermal Environment was annotated on the basis of accessibility of current material. Citations were selected on the basis of pertinence of information to the school environment, current publishing dates, quality of information and manner of presentation.

All documents were selected with the following point of view: "Will this source provide useful information to the school administration, architect, or planner concerned with developing a more functional classroom environment, physiologically more suited to student metabolisms and psychologically more comfortable to enhance learning efficiency."

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SECTION

1

THE THERMAL ENVIRONMENT AND LEARNING--

PHYSIOLOGICAL FACTORS AND THE CLASSROOM

Covers various physiological factors planners must consider in establishing optimum thermal environments for learning. Includes discussion of ideal air and body temperatures for various classroom activities.

1. Daugherty, C. R. "Winter Humidification Key to Greater Comfort," American School Board Journal, 149 (1964), 44.

   Healthful, comfortable conditions in the school require more than maintenance of the proper temperature. Another factor is being recognized increasingly as vital to good health and comfort in the school -- relative humidity.

2. Engelhardt, N. L., and N. L. Engelhardt, Jr., and S. Leggett. "Planning Elementary School Buildings," An Architectural Record Book, (1953), 228-231.

   A listing of factors includes: (1) educational needs, (2) physiological needs, (3) special needs, (4) conditions of air for prevention of disease, (5) heating and ventilating systems, and (6) fuels.

3. Hanlon, John J. Design for Health, the Teacher, the School, and the Community. Lea and Febiger, 1963. 292 pp.

   The comfort of children depends not only upon the temperature and the air circulation, but also upon the relative humidity. High humidity of the atmosphere prevents the human body from ridding itself of heat through perspiration, and the individual feels uncomfortable. Low humidity has the opposite affect.

*4. Harmon, Darell B. Controlling the Thermal Environment in the Co-Ordinated Classroom. Minneapolis: Honeywell, Inc., 1953. 45 pp. EF 002 330

   Characteristics of the human organism in general and the learning child in particular indicate three factors that must be taken into account in the design of the thermal environment in classrooms: (1) the child is different from the adult, (2) thermally induced stresses can alter the growth, development, and learning of children, (3) the child's problem-solving capacity is affected by the effective temperature of his classroom.

*5. Harmon, Darell Boyd. Some Biochemistry and the Thermal Aspects of Intelligence. Unpublished Paper. 1951. Pp. 1-7. EF 002 331

   Discusses several areas of concern for those involved in designing the thermal environment: (1) the maturing child requires a different set of thermal standards than the

mature adult, (2) there must be an increased concern for controlling the thermal environment in all of its aspects (temperature, air movement, and humidity), and (3) rigid control of all thermal factors of the classroom in order to maintain internal body temperature levels consistent with various activities during the course of the day. Includes a bibliography.

6. Herrington, John H. "The Effect of Thermal Environment on Human Action," American School and University, 1952-53, 24 (1952), 367-76.

   Directed to school administrators, engineers, and architects concerning three phases of the thermal environment in schools: (1) a description of the human body as a heat machine, with emphasis on the thermal and physiological factors which result in different optimal conditions for various types of work, (2) an analysis of the environmental thermal factors, and (3) a description of special hygiene problems in the thermal environment.

*7. Iowa Center for Research in School Environment. Thermal Environment and Learning. Des Moines: Living Laboratory, 1961. 10 pp. EF 001 001

   This report serves two purposes: (1) it summarizes research done at the Iowa Center for Research, and (2) points out that as a minimum, school buildings should be equipped with the best ventilation equipment possible. Heating is not the major problem - ventilation is. A good thermal environment is as important as a good aesthetic environment.

8. MacConnell, James. School Planning. California: Stanford University School Planning Laboratory, 1954. Pp. 40-41.

   Two points are discussed: (1) in controlling the thermal environment, body radiation of the occupants must be considered, and (2) teacher training programs should be initiated on the educational value of temperature control.

9. Mincy, Homer F., Jr. A Study of Factors Involved In Establishing a Satisfactory Thermal Environment in Classrooms. Unpublished Doctoral Thesis. University of Tennessee, 1961.

10. Nolan, James J. "Influence of Classroom Temperature on Academic Learning," Automated Teaching Bulletin, 1 (1960), 19-20.

*11. Peccolo, Charles. The Effect of Thermal Environment on Learning: A Pilot Study. DesMoines: Iowa Center for Research in School Administration, 1962. 30 pp. EF 001 000

Describes research project investigating the effect of the thermal environment on learning between a group of elementary students in a model thermal environment and marginal thermal environment. Students in the optimum thermal environment performed generally at a higher level than those in the typical thermal environment.

12. Slote, L. "Achieving Thermal Comfort in Educational Buildings," American School and University, 1962-63, 34 (1962), C1-C4.

Thermal comfort is not a luxury. It is a physical and mental requirement for effective use of a classroom. School discomfort means inattention, restlessness, poor behavior habits, and a minimum of ability to maintain sustained attention to any mental task. Emphasizes the need for air conditioning in today's schools.

13. Smiley, Dean F. "What Effect Does Temperature Have on Student Health and Efficiency," Atlantic City, (1960).

14. Sumption, Merle R. "Thermal Environment." In Planning Functional School Buildings. New York: Harper Brothers, 1957. Pp. 260-265.

Includes discussion of air temperature and body temperature for optimum comfort during task performance. Also discusses physiology of body temperature, humidity control, and ventilation. A final section describes mechanical systems available to the school architect.

*15. The University of Iowa. Education, Children and Comfort. Des Moines: University of Iowa, 1965. Pp. 1-8. EF 001 830

Two similar classrooms were set up in the Lennox Living Laboratory, Des Moines, Iowa, one for experimental groups and one for control groups. Temperature, air circulation

and humidity can be controlled and measured in both rooms. The rooms are of similar size, layout and construction, the thermal environment being the only variable. The following questions were studied in this experimental schoolhouse: (1) is there a difference between boys' and girls' reported comfort? (2) is there a difference between boys' and girls' reported feelings of comfort in the same environment? (3) what is the effect of temperature and humidity on reported student comfort? (4) what is the actual operating time of the heating, cooling, and ventilating equipment when maintaining the ideal thermal environment? Results are given to these four questions.

16. "Thermal Comfort Affects Learning," Nation's Schools, 63 (1959), 86-90.

    Cooling rather than heating is the primary problem in all classrooms. Discusses: (1) the body as a heat producing machine, (2) oxygen requirements, and (3) excessive temperatures.

17. "Two Studies on Thermal Environment and Learning," American School Board Journal, 147 (December, 1963), 22-24.

    Reports on Lennox Research School studies on the thermal environment and learning. Compares learning, efficiency in good and poor thermal environments.

18. Williams, W. A Statistical Study of Oral Temperature In School Children with Special Reference to Parental, Environmental, and Class Differences. London: Dulau and Company, 1924. 124 pp.

    Includes: (1) influence of temperature of environment, (2) individuality in temperature, (3) physiological factors in temperature individuality, (4) pathological factors in temperatures, (5) hereditary factor in the rheumatism of children, (6) relations of height, weight, and age to temperature, (7) comparison of elementary school data with data obtained from upper middle class schools and older children, (8) comparison of absolute temperatures at each age in the public elementary schools and in middle class schools, (9) comparison of variabilities in temperature in the two types of schools.

SECTION

2

PHYSIOLOGICAL FACTORS IN THE THERMAL ENVIRONMENT

Includes general physiological reactions to the thermal environment. Much work has been done in this area, however, most studies are limited in scope and few are directly related to the school environment. Citations in this section are included for their value as research documents and should provide additional clues to those interested in a more complete understanding of the thermal environment.

*1. Ackerman, Joseph R. "The Thermally Related Environment and Its Effect on Man." SER 2 Environmental Evaluations. Theodore C. Larson, Project Coordinator. Ann Arbor: University of Michigan, 1965. Vol. 2, pp. 73-97. EF 001 392

Discusses several areas of concern, including human physiological processes associated with the thermal environment and the effect these physiological adjustments may have on various human activities, specifically on work and mental task performance, on the learning process, and on human comfort.

2. Aldrich, Loyal B. "Supplementary Notes on Body Radiation," Smithsonian Miscellaneous Collection, 85 (1932), 1-12.

Discusses: (1) wall temperatures and body radiation, (2) accuracy of skin temperature measurements, and (3) transmission of radiation through the skin.

3. Bedford, T. The Warmth Factor in Comfort at Work: A Physiological Study of Heating and Ventilation. Industrial Health Research Board, Report No. 76. London: British Medical Research Council, 1936.

Statistical comparison of comfort indices and actual comfort.

4. Bruce, W. Man and His Thermal Environment. Ottawa: National Research Council of Canada, Division of Building Research.

Survey and general review of existing literature. Contains 380 bibliographical entries. Comprehensive source for anyone interested in man and his environment. This is not only limited to the thermal environment.

5. Gagge, A. P., J. A. Stolwijk, and J. D. Hardy. "Comfort and Thermal Sensations and Associated Physiological Responses at Various Ambient Temperatures," Environmental Research, (June, 1967), 1-20.

A study of the perceptions of comfort and thermal change and corresponding physiologic adaptations.

6. Leithead, C. Heat Stress and Heat Disorders. London: Cassell, 1964. 304 pp.

7. MacPherson, Ronald K. Physiological Response to Hot Environments, An Account of Work Done in Singapore, 1948-53, At the Royal Naval Tropical Research Unit. London: H. M. Stationery Office, 1960. 323 pp.

8. Miura, T. "On Optimum Room Temperature for Light Work," The Journal of Science and Labor, 44 (March, 1968), 1-9.

A study of optimal room temperatures as perceived by Japanese workers engaged in different tasks.

9. Morse, R. N., and J. J. Kowalczewski. "A Rational Basis for Human Thermal Comfort," ASHRAE Journal, (September, 1967), 72-77.

A method for studying and determining optimum thermal environments in steady state situations.

10. Muncey, R. The Influence of Air Temperature Near the Floor on the Temperature and Comfort of the Human Foot. Melbourne: Commonwealth Science and Industrial Research Organization, Australia, 1959. 10 pp.

11. Newburgh, L. H., ed. Physiology of Heat Regulation. Philadelphia: W. B. Saunders Company, 1949.

Best on man's thermal heat budget, including equations.

12. Teichner, Warren H. "The Assessment of Mean Body Surface Temperature," Journal of Applied Physiology, 12 (1958), 169-176.

13. Teichner, Warren H. "Manual Dexterity in the Cold," Journal of Applied Physiology, 11 (1957), 333-338.

14. Teichner, Warren H. "Reaction Time in the Cold," Journal of Applied Psychology, 43 (1958), 54-59.

15. Teichner, Warren H., and J. L. Kobrick. "Effects of Prolonged Exposure to Low Temperature on Visual-Motor Performance," Journal of Experimental Psychology, 49 (1955), 122-126.

16. Texas Engineering Experiment Station. Some General Considerations in the Natural Ventilation of Buildings. College Station, Texas: The Texas A & M College System.

17. Winslow, Charles Edward A. Temperature and Human Life. Princeton: Princeton University Press, 1949. 272 pp.

SECTION

3

HEATING-VENTILATING AND AIR-CONDITIONING

IN THE CLASSROOM

Discusses important heating, ventilating and air-conditioning factors in providing a healthy, clean and economical thermal environment for schools. Majority of sources indicate that air-conditioning is more important than heating and should be considered a necessity not a luxury.

1. "Air Conditioning and Architecture," Progressive Architecture, 44 (1963), 152-210.

   Progressive Architecture devotes the entire issue to problems of air conditioning in architecture.

2. "Air Conditioning and the Learning Environment," Overview, 2 (October, 1961), 50-53.

   Emphasizes the role air conditioning plays in providing an ideal thermal environment for the classroom. Advantages include: (1) greater student enrollment in air conditioned schools, (2) higher degree of work output, (3) faculty and student body are more comfortable, and (4) maintenance costs are satisfactory.

3. "Air Conditioning for a Twelve Month Program," Architectural Record, 135 (February, 1964), 151-153.

   In planning ahead for a twelve month school year, the school board for this rural high school adopted the architect's suggestion that the building be designed with air conditioning from the outset.

4. "Air Conditioning: Schools," Progressive Architecture, 39 (March, 1958), 134-137.

   Presents several examples of air conditioned schools and architects discuss advantages and limitations of various mechanical systems.

5. Barnes, R. E. "School Floors Warmed by Electric Heating," Architectural Record, 134 (July, 1963), 165-66.

   Electric cable heats floor slabs in Chicago kindergartens. Slab surface is kept at 72 degrees by control device measuring slab temperature. Timer programs operating hours.

6. "Building Design for a Flexible School with Air Conditioning," Architectural Record, 136 (September, 1964), 244-45.

   Describes first fully air conditioned school to be built in Missouri.

7. "Built-In Flexibility for Air Conditioning," Architectural Record, 137 (April, 1965), 228-230.

Architects fit air conditioning into the school construction budget by avoiding expensive perimeter walls.

8. Carroll, J. R. and H. D. Bareither. "Comfort Conditioning for Educational Buildings," American School and University, 1961-62, (1961), C1-C8.

Air in a classroom must be controlled for temperature, distribution, motion, cleanliness, humidity, purity, and odor. Authors discuss advantages and limitations of unit ventilation systems, central air systems, and radiant heating.

9. "Characteristics of Classroom Heating and Ventilating Systems," Architectural Record, 124 (December, 1958), 158-167.

Classifies ten types of heating systems common to schools and sets forth each system's advantages and limitations. Each system is rated for installation and maintenance. Engineers provide editorial remarks for each system.

10. Dubin, F. S. "Heating, Ventilating, and Cooling for School and College Buildings: Developments and Trends," American School and University, 1960-61, 32 (1960), 57-64.

11. "Eighty-Five Classrooms for Year-Round Use," Progressive Architecture, (October, 1963), 160-161.

Describes air conditioning details for a 319,000 square foot high school in Mount Vernon, New York.

12. School Building Congress, Building Research Institute. Evaluation of Climate Control and Its Contributions to An Effective Educational Program. Washington, D. C.: Building Research Institute, 1963. 200 pp.

Compares two schools, one equipped with air conditioning and one without, in terms of cost maintenance and depreciation, educational outcomes, and incidence of physical illnesses and psychological problems among students. Two junior high schools were employed in the study, each meeting similar standards of area, enrollment, and cost of construction. They are located in Pinellas County, Florida. Preliminary findings are reported.

13. "Florida Sees Full Scale Air Conditioned School Test," Progressive Architecture, 41 (August, 1960), 54.

    Comparison between two new schools in Florida; one air conditioned, the other non-air conditioned. Schools are evaluated for attendance, increased use of facilities by communities, and educational effectiveness. Results are not given.

*14. Foutz, W. D. "Comfortable Climatic Conditions in Schools Buildings." In Proceedings of National Council on Schoolhouse Construction. East Lansing: National Council on Schoolhouse Construction, 1962. Pp. 66-70. EF 000 805

    Discusses optimum school building climate conditions. Points out that an uncomfortable thermal environment may be fatiguing and distracting to the student; therefore, maintenance of proper thermal environment is an important factor in making most productive use of teachers' time. Specifications are given.

15. Grupta, H. C. "How to Select a Mechanical System," Nation's Schools, 74 (October, 1964), 58-59.

    Describes five basic types of mechanical systems and presents a criteria for selecting the appropriate system for your school's needs.

16. Haines, John E. Automatic Control of Heating and Air Conditioning. 2nd Edition. New York: McGraw-Hill, 1967. 389 pp.

17. Handler, Benjamin. Economic Planning for Better Schools. A Department of Architecture Research Publication. Ann Arbor: University of Michigan, 1960. Pp. 42-43.

    Presents a brief review of thermal environment research as well as a summary of various types of heating and ventilating systems for various school environments.

18. Herrick, John H. From School Plant to School Program. New York: Holt and Company, 1956. Pp. 441-459.

    Discusses: (1) heating and ventilating objectives, (2) the heating system, (3) methods of ventilation, and (4) sanitary facilities in relation to school planning.

19. Holy, T. C. "Location, Construction, and Equipment of Schoolhouses for Health," American School Board Journal, 104 (January, 1942), 19-20.

    Discusses various planning considerations in creating a healthful school environment; includes discussion of heating and ventilation factors.

20. Hood, W. K. "Heat in the School Classroom," American School Board Journal, 132 (April, 1956), 55-57.

    Discusses the flexibility and heating-cooling system must have in order to meet the changing needs of a typical classroom day.

21. "Ideas for More Effective School Heating and Air Conditioning," American School Board Journal, 146 (January, 1963), 33-35.

    Reports on a seminar held by the Better Heating and Cooling Council dealing with the thermal environment. Various architects and engineers give their candid views on some practical approaches to provide schools with better thermal environments.

*22. Kelton, Clifford R. "The Central Air Conditioning System." In Proceedings of School Business Officials. Chicago: Association of School Business Officials, 1965. Pp. 175. EF 000 742

    General characteristics of common types of air conditioning systems are described. A brief discussion of factors to consider when choosing a particular system is provided.

23. Lewis, S. R. "Heating and Ventilating School Buildings," American School Board Journal, 132 (February, 1956), 53-55.

    The design of heating and ventilating plants for school buildings must be adapted to the building construction characteristics developed by the architects.

24. "Lights, People, Heat; A Wisconsin School, Kimberly High School," Architectural Record, 134 (November, 1963), 194-195.

    New 1,200 pupil Kimberly, Wisconsin High School utilizes a heat pump system to retrieve heat generated within the building by fluorescent lamps and occupants. In this way the school heats itself.

25. Manning, W. R. and L. R. Olsen. "Air Conditioning: Keystone of Optimal Thermal Environment," American School Board Journal, 149 (August, 1964), 22-23.

Air conditioning is considered to be the most critical factor in providing an optimum thermal environment for learning.

26. McGuinness, W. J. "Cost of School Ventilation," Progressive Architecture, 44 (August, 1963), 146.

"Recent research revealing that the ventilation rate in a school may be reduced and consequently become more economical."

27. McGuinness, W. J. "Heating by Light," Progressive Architecture, 45 (May, 1964), 194.

"An environmental control design in which the lighting provides more than enough heat energy for a building under critical outdoor winter temperatures is discussed."

28. McGuinness, W. J. "School Air Conditioning," Progressive Architecture, 45 (March, 1964), 174.

"A comparative analysis of two questionnaires concerning the acceptance of air conditioning in public schools is discussed."

29. McGuinness, W. J. "Year-Round School Operation," Progressive Architecture, 42 (September, 1961), 218.

Author of this article states the case for air conditioned schools. Three factors are mentioned: (1) comfort standards demand air conditioning, (2) saving construction costs in many new buildings, (3) offer interesting architectural possibilities.

30. McQuade, Walter. Schoolhouse. New York: Simon and Schuster, 1958. 269 pp.

Thermal environment pages 175-190. Discusses various factors concerning the thermal environment in school planning, including: (1) when to heat and when to cool the classroom, (2) selecting the right type of fuel, (3) selecting the type of system, (4) checklist of

advantages and disadvantages of various types of heating-cooling systems, (5) air movement, and (6) air conditioning.

31. Miles, Victor C. Thermostatic Control: Principles and Practices. London: Newnes, 1965. 215 pp. Bibliography.

32. Pena, W. M., and J. B. Thomas. "Myths and Facts about Ventilation," American School and University, 1963-64, 35 (1963), 41-44.

*33. Perkins and Will. Climate Conditioning for the Learning Environment. Chicago, Illinois: Perkins and Will, Architects. 12 pp. EF 002 088

Deals with heating, cooling, and ventilation of the classroom as related to students' learning abilities. It is designed to assist school boards, administrators, architects, and engineers in understanding the beneficial effects of total climate control, and in evaluating the climate conditioning systems available to schools. Discussion includes: (1) the physiology of comfort, (2) comfort design, (3) climate control engineering, (4) climate control systems, and (5) the total electric concept.

34. "Planning Facilities for Higher Education." In Proceedings of the National Council on Schoolhouse Construction. East Lansing, Mich.: National Council on Schoolhouse Construction, 1960. Pp. 91-93.

Discusses the following factors: (1) optimum room temperature for various tasks, (2) air movement required for comfort, (3) heating and ventilating systems, (4) air conditioning should be considered if economically possible.

35. Rutgers, Normal L. "Is Heating Important in Our Schools?" In Proceedings of Association of School Business Officials. Chicago: Association of School Business Officials, 1961. Pp. 5.

Includes discussion of: (1) results of Lennox "living laboratory" research on thermal environment and learning, (2) ventilation needs and benefits, (3) air conditioning as related to location and school design, and (4) future projections.

36. School Thermal Environment. Minneapolis: Bureau of Field Studies and Surveys Publications, University of Minnesota, 1961.

37. Smart, Edwin. Design and Specification for the Heating, Ventilating, and Air Conditioning of a Typical Thirty Classroom School Building. M. S. Thesis. Madison: University of Wisconsin, 1948. 128 pp.

This thesis gives complete calculations, design, and specification of the heating, ventilating, and air conditioning system for a typical classroom in Madison, Wisconsin.

38. Sylvia, Frank J. "The Present and Future Status of Natural Gas for Heating School Buildings." In Proceedings of Association of School Business Officials. Chicago: Association of School Business Officials, 1960. Pp. 11.

Discusses the following: (1) supply, (2) cost, (3) advantages, (4) efficiency, and (5) the "year-round" concept of gas. In conclusion, selection of heating and cooling systems and fuel to power it will affect the economy and budget of the school district for years to come. One must investigate claims closely, know all costs, study regulations, and check comparisons.

39. "Thermal Comfort and Efficiency," Overview, 3 (August, 1962), 25.

Briefly reviews research related to thermal environment and human comfort. Air conditioned environments increase work output and cut absenteeism.

40. "Thermal Environment, Portfolio of Heating and Ventilating and Air Conditioning for Today's Schools," Nation's Schools, 68 (May, 1959), 85-142.

May issue of Nation's Schools devotes 25 pages to various aspects concerning the thermal environment in school facilities.

41. Thorndike, E. L., and W. A. McCall. Ventilation in Relation to Mental Work. New York: Teachers' College, Columbia University, 1916. 83 pp.

Includes: (1) effect of conditions of the air on mental work, the condition being changed daily, (2) effect of

conditions of the air upon the rate of improvement of mental function, (3) effect of conditions of the air upon the accuracy of judgment, (4) effect of certain conditions of the air upon the choice of alternatives to mental work, and (5) summary and interpretations.

42. Todd, G. W. "Electrical Heat in Schools Can Improve Attendance Record," Electrical West, 115 (October, 1955), 69-71.

43. Valandani, Parviz. Design of an Air Conditioning System. M. S. Thesis. Madison: University of Wisconsin, 1960. 48 pp.

    Describes an air conditioning system to meet the various needs of a school building. Discusses: (1) factors affecting design, (2) ventilation requirements, (3) heat gain calculations, (4) plant calculations, and (5) heat load calculations.

44. Whittlesey, R. L. "Choice of Systems, Equipment," Nation's Schools, 63 (May, 1959), 106-108.

    School planners may choose from four patterns of heating and ventilation: (1) a system combining heating and ventilating and cooling in the same ducts, (2) a unit ventilator system, using heating and ventilating and cooling units in one space, (3) a straight radiant panel system, and (4) radiant heating.

45. Wickenberg, Ralph F. Summer Air Conditioning for School Buildings. M. S. Thesis. Madison: University of Wisconsin.

    Presents design requirements for installation of an air conditioning system for the Engineering Building on the University of Wisconsin campus. Includes specifications and calculations.

46. Wilson, Maurice J. "Trends in Air Conditioning for Schools and Colleges," American School and University, 1962-63, 34 (1962), C5-C12.

    A 1960 census revealed that 913 schools and college buildings were partially or completely air conditioned, substantially more new buildings were air conditioned in

1961. One major manufacturer reports that schools are its fifth largest market for large central air conditioning equipment, ranking ahead of department stores and apartment buildings. Author investigates motivations for increase in air conditioned schools.

47. Wright, H. "A Definitive Experiment with Air Conditioning," American School Board Journal, 142 (January, 1961), 29-32.

Does air conditioning really improve the learning process is the question being answered by a definitive project of the Pinellas County, Florida, schools with two identical schools, one with and one without air conditioning. Progress report is given.

48. Wright, H. "Air Conditioned Schools," Architectural Record, 128 (November, 1960), 186-190.

A number of factors, including economics and a demand for better environmental control, are tending to produce compactness in many new schools, with air conditioning its natural concomitant.

49. Wright, H. "Air Conditioning, Architecture, and Education," Architectural Record, 135 (February, 1964), 146-153.

Twenty notable architects and educators discuss the pro's and con's of air conditioned schools. Topics covered include: (1) windowless classrooms, (2) interior courts, (3) changing educational requirements, and (4) flexibility.

50. Wright, H. "Classroom Heating and Ventilating," American School and University, 1951-52, 23 (1951), 197-216.

Emphasizes the need for architect and school administrators to place the same value of concern on the thermal environment as has been placed on the lighting and sonic environments. Discusses many aspects of the thermal environment, including: (1) healthful aspects, (2) artificial vs. natural conditions, (3) heat gain and loss, (4) classroom ventilation, (5) fuel savings, (6) ideal thermal environment, and (7) economic factors.

51. Wright, H. "Coordinating Engineering and Architecture in School Design," American School and University, 1959-60, 31 (1959), 23-28.

    There should be an integral relationship between engineering aspects of school construction and school architecture - a relationship in which the architectural approach should not only influence engineering but the engineering approach should also influence architecture at the design stage. A prime example of this process working itself out in practice is the advent of air conditioning in school facilities.

52. Wright, H. "Thermal Comfort Report," Progressive Architecture, 37 (January, 1956), 142-152.

    Discusses several aspects of thermal comfort controls designed and tested at Washburn Elementary School, Auburn, Maine, including: (1) air distribution, (2) night-time heating, (3) cooling, (4) solar heat gain, (5) dew-point controller, (6) skyshine, and (7) aluminum coated curtains.

53. "Year-Round Comfort," Overview, 1 (May, 1960), 58.

    "Basic to planning a coordinated mechanical air system is the relationship between window area and air change. Four factors must be considered in the design of classroom windows: (1) light, (2) heat, (3) air, and (4) aesthetics."

SECTION

4

ADDITIONAL CONSIDERATIONS IN PLANNING THE THERMAL ENVIRONMENT

Includes sources dealing with architectural orientation, solar screening devices, landscaping the site and the need for planning coordination.

*1. Building Research Institute. Solar Effects on Building Design. Washington, D. C.: Building Research Institute, 1963. 180 pp. EF 001 253

Topics discussed: (1) solar energy data applicable to building design, (2) thermal effects of solar radiation on man, (3) solar effects on architecture, (4) solar effects on building costs, (5) solar shading and glass selection to reduce cooling demand, (6) design of windows, (7) designs of skylights, (8) design of electric illumination, (9) design of windows in Europe, and (10) design of windows in Sweden.

2. Davis, A. Q. and N. C. Curtis, Jr. "Architecture Creates Environment," Nation's Schools, 63 (1959), 95-100.

Architects use a ceramic block sunscreen to control the natural thermal environment. Overhangs and exterior plant materials are also used as a design element to control heat gains from the sun.

3. "Design Controls Temperature," Nation's Schools, 63 (May, 1959), 90-92.

Discusses the role architectural orientation of school building to site plays in controlling the thermal environment. Architectural decisions made before the mechanical engineer goes to work may have a substantial bearing on whether a building will be comfortable at all, in either winter or summer.

4. Dostal, E. V. "Providing for the Thermal Environment," American School Board Journal, 144 (January, 1962), 34-37.

Explains the operation and advantages of hydronic heating systems. This system is designed to do more than heat the air; it also automatically controls heat flow, as well as eliminate "hot spots," drafts, and undesirable or unwanted odors.

5. "Educational Planning Comes First," Nation's Schools, 63 (May, 1959), 94.

In planning a good thermal environment for a school, the architect and mechanical engineer must first know the needs of the school's educational program. What is the probable

length of the school year? What is the summer school registration, and what is the school's basic curriculum?

6. Gustafson, C. A. and G. E. Fickett. "What School Boards Should Know about Temperature Control Systems," American School Board Journal, 140 (January, 1960), 37-38.

   School board members should review and select temperature control systems by the following criteria: (1) comfort, (2) flexibility, (3) simplicity, and (4) economy.

7. "Insulate for Comfort and Economy," Nation's Schools, 63 (May, 1959), 109-110.

   Discusses various types of building materials and their value as insulators. Deals primarily with roof design and insulation.

8. "Man-Made Climate," Progressive Architecture, 39 (March, 1958).

   Devotes entire issue to problems of thermal environmental control.

9. Marsh, Z. A. "Balancing the Thermal Environment for Audio-Visual Education," Bulletin of the Indiana University School of Education, 31 (September, 1955), 141-147.

10. Novak, P. M. "Microclimatology and the School's Indoor Climate," Nation's Schools, 63 (May, 1959), 101-105.

    School administrators and architects should consider factors of microclimatology when selecting sites and building orientation. Emphasis is placed on the role landscaping can play in controlling the thermal environment as well as in beautifying the site.

*11. Olgyay, Victor. An Evaluation of External Shading Devices. Princeton: Princeton University Press, Educational Facilities Laboratories, 1963. Pp. 67-71. EF 000 494

    Discusses heat and radiation transmission for glass and solid walls with respect to angles of incidence, orientation and various shading conditions. Performance of shading systems was measured and expressed by shading coefficients. Diagram showing shading coefficients was

then used to record the effects of various shading systems due to color, location, design, and materials.

12. Papke, Ross R. School Plant Research by Educators and Architects. Unpublished Doctoral Thesis. University of Wisconsin, 1966. 308 pp.

Reviews and comments on school planning research found in current literature. Emphasizes the need for thorough planning in school design. Includes comprehensive bibliography on various aspects of school planning, including the thermal environment.